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LOFT RESULTS DEMONSTRATE RESISTANCE OF UNPRESSURIZED PWR FUEL TO LOSS-OF-COOLANT ACCIDENTS

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CREDIT LINE -

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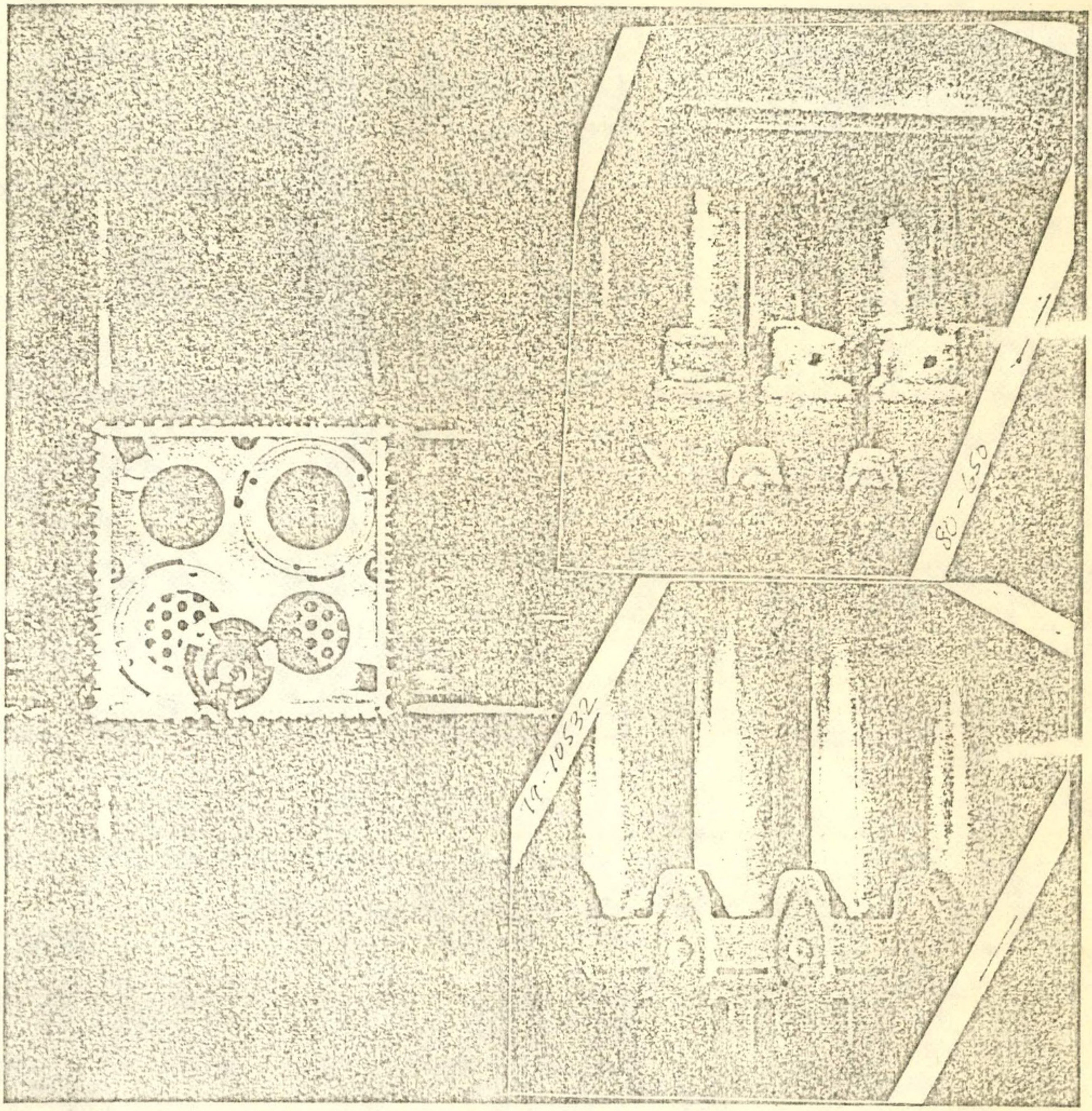


Cleared for Publication

LOFT Fuel Photographs show undamaged fuel conditions after exposure to three large-break loss-of-coolant experiments. Left: telephoto lens photograph from reactor vessel head of adjacent fuel rods and core mounting plate after removal of center (highest power) fuel assembly. Right: photographs through periscope of tops of hottest fuel rods in LOFT core and fuel rods and spacer grid immediately upstream of the peak heat flux elevation.

POWER or FUEL

ACCIDENT RESPONSE

LOFT Results Demonstrate Resistance of Unpressurized PWR Fuel to Loss-of-Coolant Accidents

The initial visual examination of LOFT unpressurized fuel and evaluation of data recorded during the first three LOFT large-break, loss-of-coolant experiments (LOCE's) indicated the LOFT fuel to be in a reusable condition. Since the September 1977 core load, the LOFT fuel assemblies have been exposed to three large-break loss-of-coolant experiments; LOCE L1-5 without nuclear heat and LOCE's L2-2 and L2-3 with a 26 and 39 kw/m peak fuel rod linear heat generation rate at test initiation. The LOFT power operation has resulted in a cumulative fuel burnup of 987 megawatt-days per metric ton of uranium and linear heat generation levels of up to 53 kw/m at the peak power location.

LOFT is a 50 megawatt pressurized water reactor system located at the Idaho National Engineering Laboratory. It is operated for the Department of Energy with a program directed by the Nuclear Regulatory Commission. EG&G Idaho, Inc. is the prime contractor (to DOE) responsible for operation of the reactor and the conduct of the experiments. The LOFT reactor system has special features that permit initiation and measurement of conditions characterizing a full range of postulated accidents (transients) including those hypothesized for the severing (large-break) of a primary coolant pipe. The large-break in the primary coolant pipe, as a minimum, results in a rapid decompression of the subcooled liquid in the reactor vessel, a subsequent decompression of the saturated liquid-steam mixture, loss of coolant from the fuel assemblies, overheating of the fuel rod cladding, and subsequent quenching by the Emergency Core Cooling System.

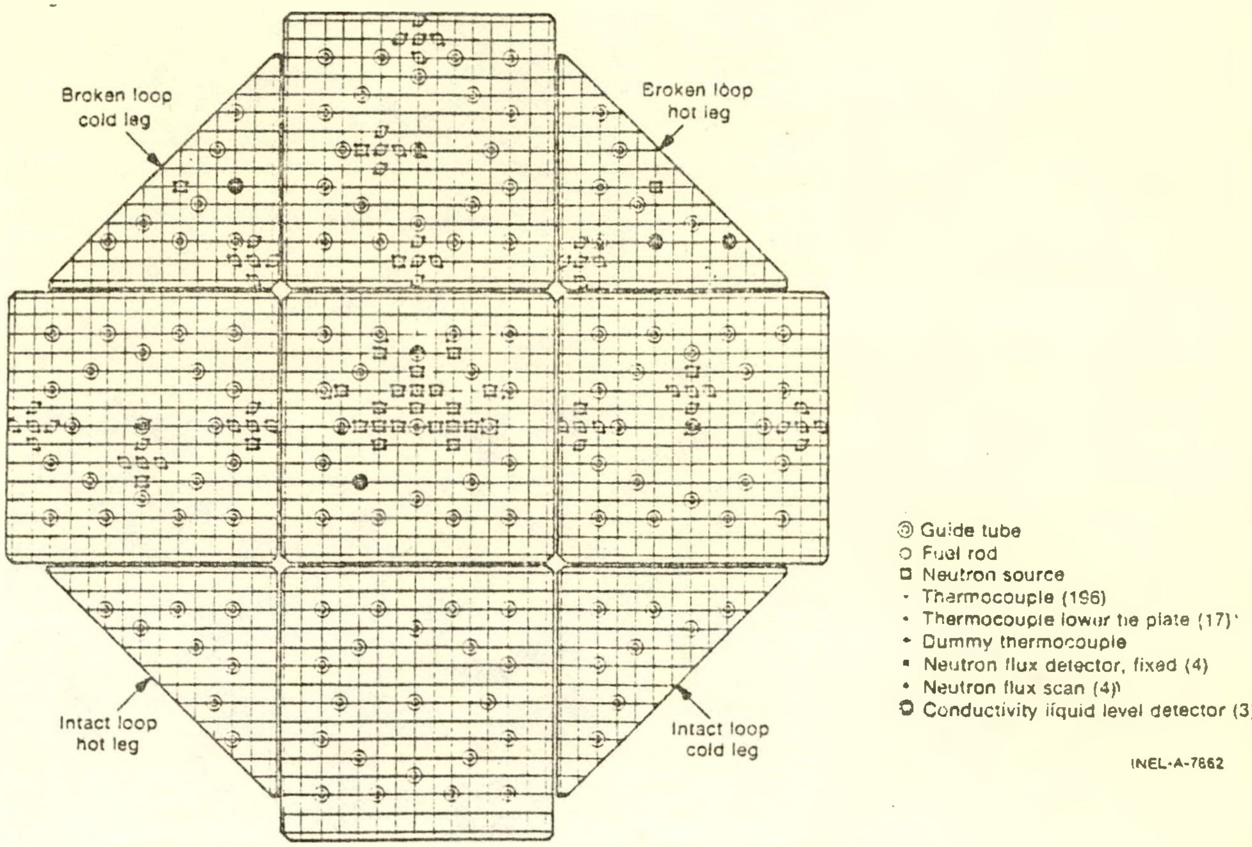
The 50 megawatt reactor core is composed of six instrumented and three noninstrumented fuel assemblies arranged as shown in the diagram. The six instrumented fuel assemblies provide 346 locations for measurement of reactor conditions during steady-state power operation and transient experiments. The LOFT fuel assembly is modeled after a typical commercial 15 x 15 fuel-rod-array fuel assembly; however, some compromise was necessary. The core length is restricted at 1.68 m because of reactor size constraints. For improved column strength during decompression loading, guide tubes are stainless steel instead of the conventional zircaloy. Control rod deceleration is provided by a dashpot in the control rod drive mechanism. To meet the requirement for exposure to repeated LOCE's, the initial core fuel rods are not prepressurized. However, one replacement center fuel assembly featuring prepressurized fuel rods and zircaloy guide tubes will be installed for later experiments. Exxon Nuclear Co. designed and fabricated the fuel bundle (core section) portion of the LOFT fuel assemblies.

The photographs indicate that the fuel rods are not bowed, the spacer grids are not warped, and the fuel rod surfaces are free of unusual blemishes or discoloration after exposure to the first three large-break LOCE's. Underwater television scanning of the center fuel bundle surfaces confirms the photograph observations. The visual observations coincide with measurements made during and after the loss-of-coolant experiments.

Measurements of fuel bundle axial motion during the decompression of the subcooled liquid and control rod drop speed during the subsequent decompression of the saturated liquid-steam mixture indicated residual deformation of the fuel assembly did not occur and the control rod drop speed was not disturbed by the loss-of-coolant conditions. Measurements of the lifting force required to extract the center fuel assembly following LOCE L2-3 also indicated the fuel bundle did not incur any residual deformation.

The 914K peak fuel rod cladding surface temperature measured during LOCE L2-3 was not expected to result in physical cladding deformation; however, the temperature is sufficient to cause zircaloy annealing and loss of the enhanced tensile properties of the as-built cold-worked and stress relieved cladding. Experiments at the INEL Power Burst Facility indicate at least three more severe large-break loss-of-coolant experiments can be performed with annealed cladding without perforation of the fuel rod cladding. Further eveidence of the undamaged condition of the LOFT fuel assemblies is that there are no fuel rod leakers as determined by measurement of negligible iodine levels in the primary coolant and 334 of 346 fuel assembly measurement locations were functioning after LOCE L2-3.

Since the removal of the center fuel assembly for the visual examination, a new fuel assembly was installed and two small-break loss-of-coolant experiments performed. The measurements made during and after conduct of the experiments continue to indicate maintenance of reusable fuel conditions. The next LOFT experiments planned are more small-break experiments and a series of operational transient experiments which do not involve simulation of a break in a coolant pipe or malfunction of a pressure boundary valve. Planned operational transient experiments include such malfunctions as loss-of-primary coolant pump power, turbine trips, loss of feedwater flow to steam generators, inadvertent control rod withdrawal, and inadvertent dilution of soluble poison (boron) in the core coolant.



Arrangement diagram of the nine fuel assembly, 50 megawatt, LOFT first core loading showing measurement locations and types of measurement devices. Since the September 1977 core load, the core has been exposed to three large-break and three small-break loss-of-coolant experiments and power operation to 53 kw/m at the peak power location. No measurable or visible damage that would prevent reuse of the LOFT fuel has occurred to date.